Calibration of the 200-MeV Linac Polarimeter

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In response to concerns about the calibration of the p+Carbon scattering used routinely to measure the polarization of the 200-MeV proton beam at the BNL linac, we undertook a recalibration based on the precise analyzing powers for p+d scattering determined at IUCF. When the recoil deuteron is observed at θ=42.6E, the analyzing power is known to be A=0.507K0.002. The objective at BNL was to make a setup for the linac that would generate a clean sample of p+d elastic events. IUCF provided the target material and the deuteron arm detectors. The proton arm detectors were taken from the 16E-detectors from the p+C polarimeter.

Several modifications were made to the setup used at IUCF to handle the large instantaneous rates from the pulsed beam at BNL. Each arm (p and d) had two scintillators required to be in coincidence (4 total). In front of these scintillators, aluminum absorbers removed lower energy protons. The thickness was chosen so that the deuterons stopped in the second scintillator on that arm. Behind this scintillator, a veto scintillator was installed to remove higher energy protons. The coincidence timing between the arms was 15 ns. Thresholds were adjusted to be just under the pulse heights of the p+d events. In this configuration, a 20 μA linac beam gave a random coincident rate in this system that was 10-20% of the real p+d rate.

Figure 2 shows a cross section of the original IUCF polarimeter with only single detectors on each arm. The target was a CD_2 polyethylene foil. An absolute polarization standard was provided by double scattering using the K600 magnetic spectrometer and its focal plane detector. The resulting calibration between 80 and 200 MeV is shown also.

Figure 3 contains a scale drawing of the proton and deuteron arm layout. CD_2 foils were mounted on the target ladder drive along with a pure a pure carbon target. The calibration involved making measurements with this new setup for p+d scattering interspersed with p+C scattering at 12E. Sample data is shown in Fig. 4. Note cuts on energy. Peak sums were taken from the time spectra.

Figure 5 shows a plot of the p+C analyzing powers as a function of the laboratory angle. The solid curve is the angular distribution reported by McNaughton at 200 MeV for proton inclusive scattering. The two open points are the original calibration, completed at IUCF in 1982. At that time, mounting difficulties required that a sideways polarized beam be used, and this made an accurate transfer of the calibration from lower energy scattering from ^{4}He difficult. The errors on the original calibration are statistical only. The new calibration value for p+C scattering (A=0.576K0.013 at 12E) is shown by the solid point. This value is 8% below the old calibration, a change that will be reflected in linac beam polarizations that are higher than before. The beam current during the calibration was limited to 20 μA because of random pileup in the p+d scattering detectors. The error bar reflects the statistics obtained for p+d scattering and at present is not limited by our knowledge of the reference analyzing power.

Further improvements are possible with additional running time. This may become available during the upcoming RHIC polarized proton running period. For this, pulses from the linac could be shared with this polarimeter and the calibration taken during normal proton production running.

Recalibration of 200-MeV Linac Polarimeter

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Objective:
Recalibrate 12°-detector system on p+C linac polarimeter

Use p+d scattering as analyzing power standard.
(A = 0.507 ☺ 0.002 for deuteron recoil at θ_{lab} = 42.6°.

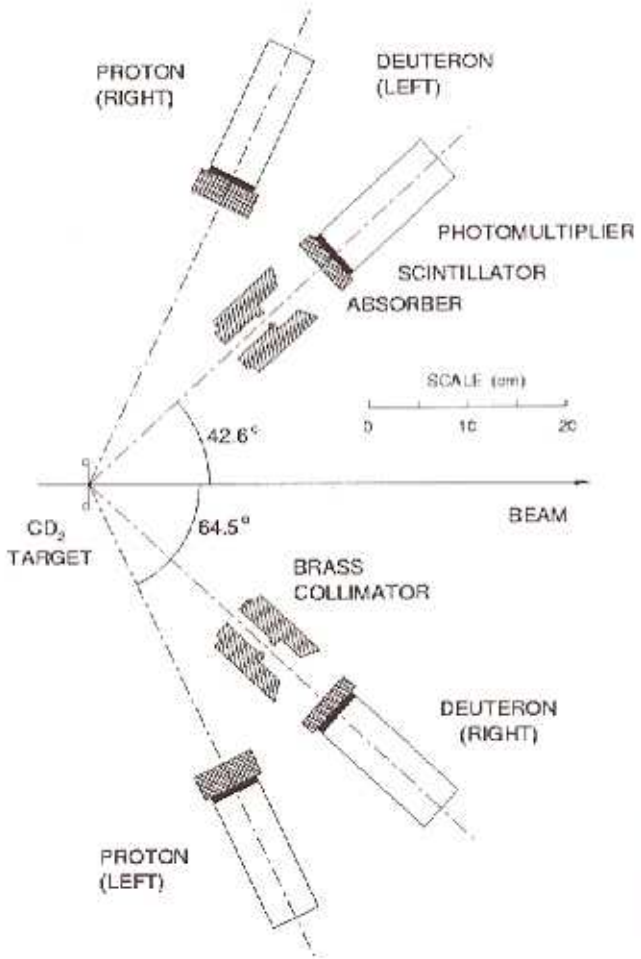
IUCF provides CD_2 target material and deuteron arm detectors.
BNL provides stands and alignment help, electronics, data acquisition.

Attempt to observe clean sample of p+d elastic events:
(plastic scintillation detectors)
- observe both deuteron and proton
- use multiple detectors on both arms (IUCF had only one)
  - proton arms are actually old 16° p+C detectors
- use one detector on deuteron as a veto
- make timing coincidence tight
- use absorbers on both arms to reduce lower energy rate
- set high thresholds on scintillators

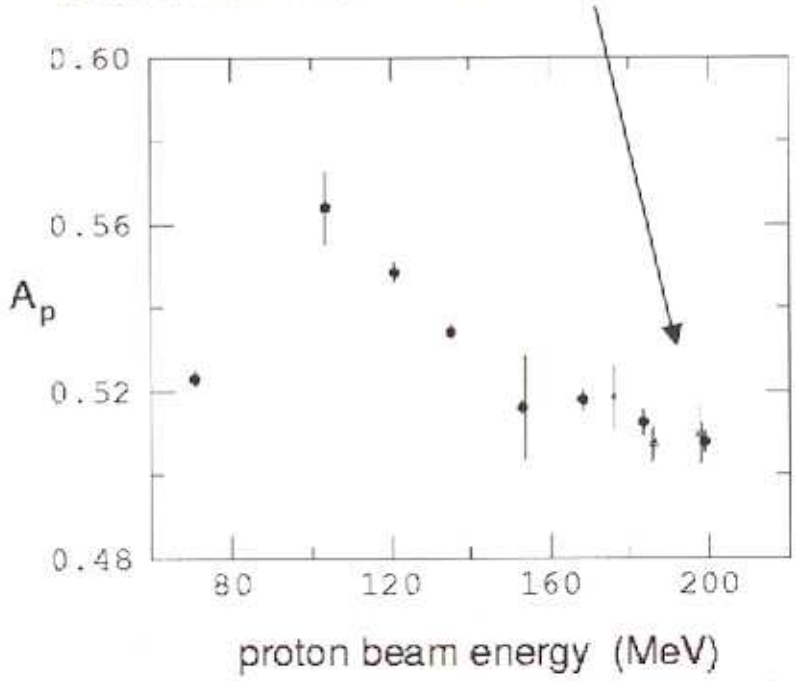
(if clean enough, count events in scalers)

Calibration of beam line polarimeter at IUCF

Polarimeter used CD_2 target and p+d elastic scattering.



The calibration made use of double scattering in the K600 spectrometer and focal plane polarimeter as the absolute reference standard. At 200 MeV, the p+d analyzing power is known to better than 0.5% absolute.

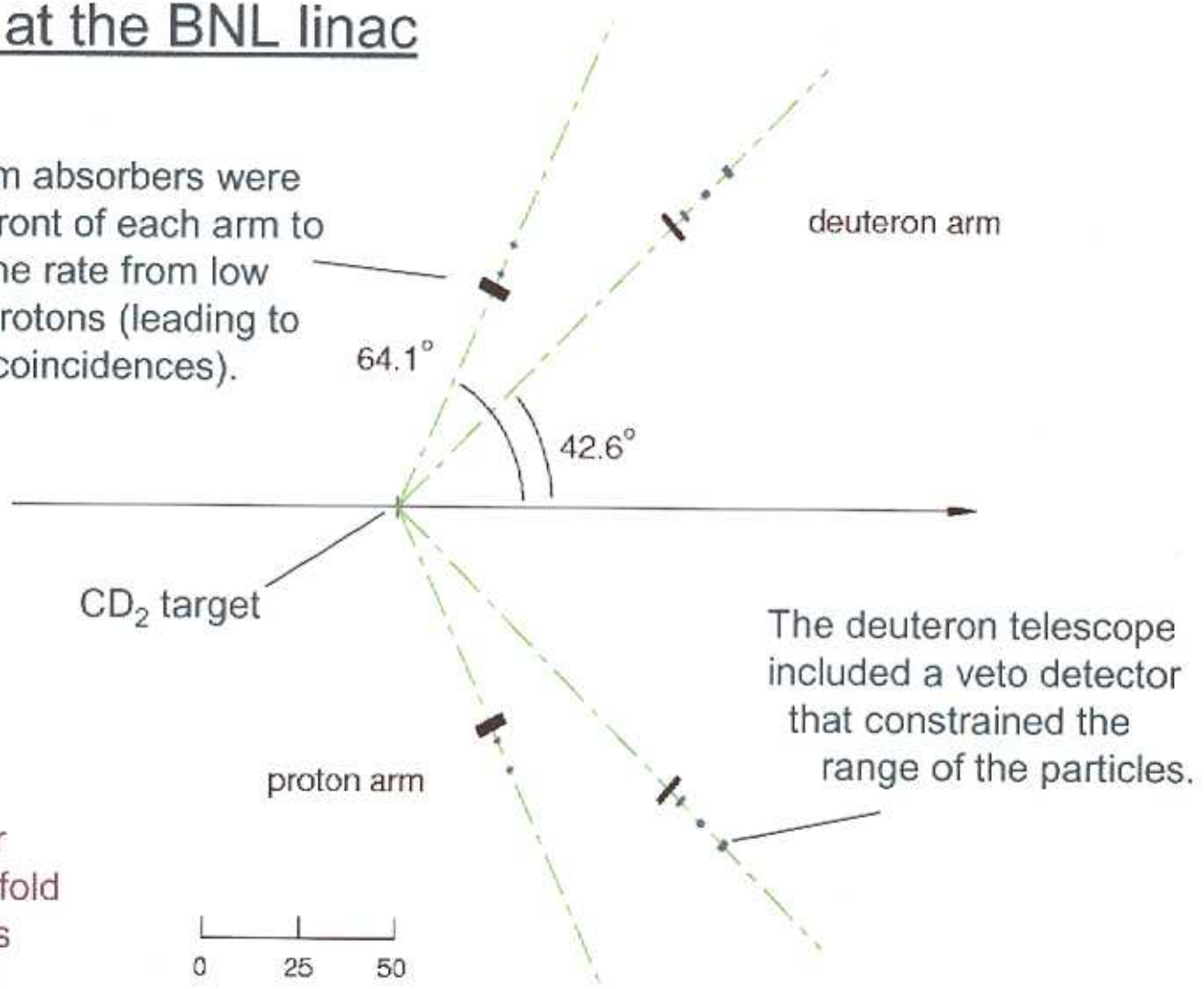


A = 0.507 ☺0.002

PLAN: Duplicate the critical geometry at the BNL linac, then set up a system to extract only p+d elastic events.

Setup at the BNL linac

Aluminum absorbers were used in front of each arm to reduce the rate from low energy protons (leading to random coincidences).



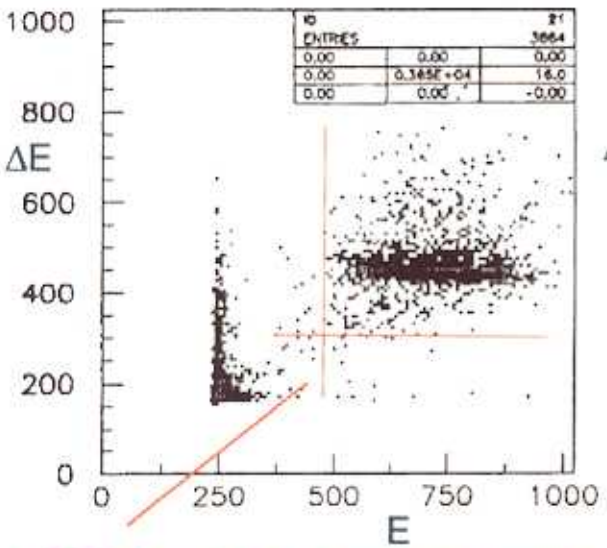
The deuteron telescope included a veto detector that constrained the range of the particles.

The event trigger consisted of a 4-fold coincidence (plus veto) with a time acceptance of 15 ns.

SAMPLE DATA

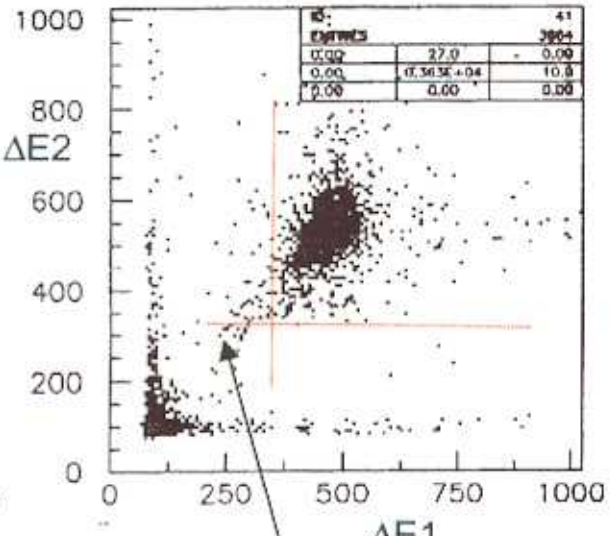
scintillator pulse heights

deuteron right



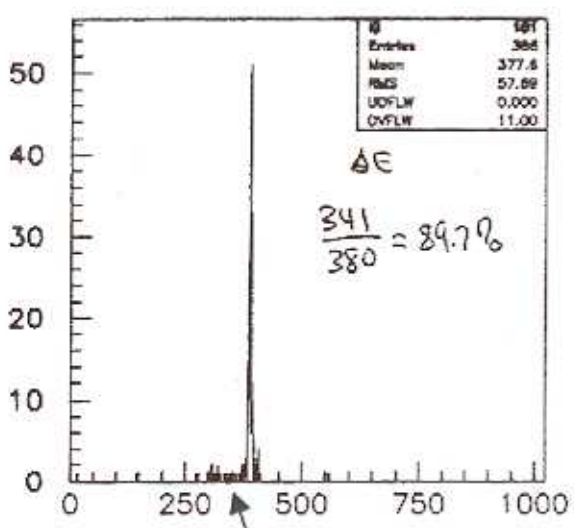
ADC thresholds (events at lower pulse height come from triggers on the other arms)

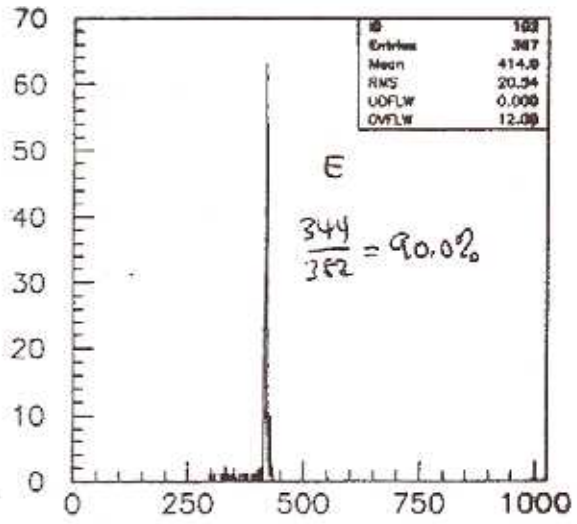
proton left



Endpoint (200 MeV) of proton locus

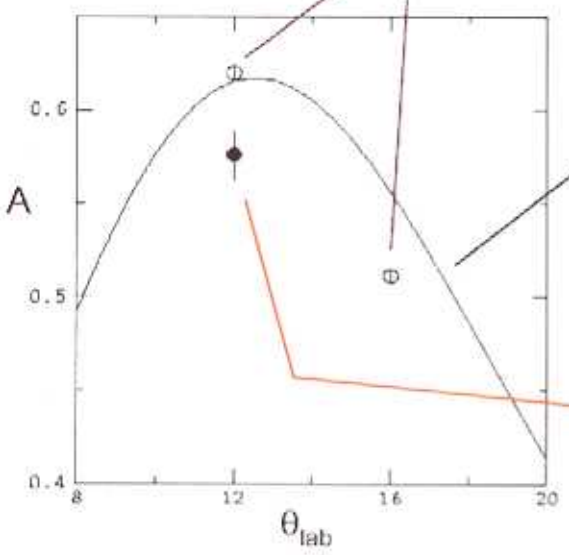
timing peaks for deuteron arm





random events show as tail (10%) below the peaks

Results



Other analyzing powers:

p + CD_2 at 12° 0.534 ☺ 0.012

p+d scalers 0.456 ☺ 0.010
(value depends on random rate)

Other Issues:

Improving 12°-detector reliability: increase detector separation to remove sensitivity to nearby sources of events.

Making system operate better for larger beam currents: opens possibility to use p+d scattering during RHIC polarized running.